National Aeronautics and Space Administration

Educational Program	
Educators & Students	Grades 5–12

EP-2002-08-385-HQ

NASA
Student Involvement Program
Design a Mission to Mars

NASA's mission is

- To understand and protect our home planet,
- To explore the Universe and search for life,
- To inspire the next generation of explorers *as only NASA can.*

Resource Guide

2002–2003
National Competitions

National Aeronautics and
Space Administration

NASA's vision for the future is:

- To improve life here,
- To extend life to there,
- To find life beyond.

NASA's mission is:

- To understand and protect our home planet,
- To explore the Universe and search for life,
- To inspire the next generation of explorers as only NASA can.

You may obtain the official Entry Packet for the 2002–2003 competitions by downloading it from the NSIP website, ***http://education.nasa.gov/nsip***, or you may contact us by e-mail (***info@nsip.net***) or by telephone at 1-800-848-8429.

This Resource Guide provides background information and learning activities for you to help your students participate in the NASA Student Involvement Program (NSIP) competition **Design a Mission to Mars.**

Use this Resource Guide together with the official NSIP Program Announcement poster (see "Resources" on p. 18), which provides full details on the NSIP Program and an entry form for submitting your entry.

The guide is designed for teachers of students in grades 5–12. This is a wide age range, so feel free to adapt the materials and activities to make them easier or more challenging.

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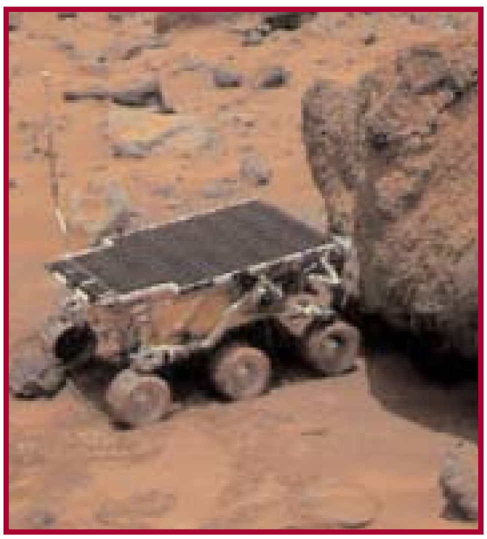
Mars Pathfinder Exemplifies Successful Mission Design

The Mars Pathfinder mission demonstrates how a dedicated group of scientists and engineers design a mission and learn from the new data it provides.



On July 4, 1997, the world was transfixed by NASA's dramatic Pathfinder mission to Mars. After a seven month, 309 million mile journey, the Pathfinder spacecraft fired its retro-rockets to slow its tremendous speed, aerobraked into the Martian atmosphere, and deployed its parachute and protective airbags. Then it bounced to a landing on Mars—the first successful return to the surface of Mars since the Viking mission of 1976.

The mission team cheered at the Mission Control Center at Jet Propulsion Lab (JPL) in Pasadena, CA. After some nail-biting delays, Pathfinder's side panels spread open like a budding flower. The amazing Sojourner rover rolled down the ramp to begin its wandering and exploring of Mars. Images were broadcast live to a TV audience of millions, and were immediately posted on the Internet for scientists and the general public.

This was a miracle of technology—but it was also a triumph for the many scientists, engineers and others who had struggled for years. For example, Donna Shirley led the overall Mars Exploration Program and worked with her team of engineers to design, build, and test the rover. Matt Golombek headed the team of scientists who defined the priority research goals, selected the landing site, and interpreted the data. Tony Spear managed the Pathfinder mission, coordinating the efforts of a diverse team of very creative, enthusiastic, and surprisingly young people.

The Pathfinder mission demonstrates the richness, mystery, joy, challenges, and collaborative spirit of science and space exploration. Scientists develop expertise, ask questions, consider ways to gather new data, and examine the data for new insights. Engineers struggle with instrument design, integration into a compact spacecraft, orbital mechanics, landing techniques, and the challenges of maintaining a spacecraft far away from the nearest repair shop. And all involved work through issues of teamwork in a dynamic environment.

What will your students learn by designing a Mars Mission?

Through this NSIP competition, your students experience some of the same challenges as NASA's scientists and engineers. Your students use real images and other data about Mars, define interesting questions, and design a mission to Mars to answer the questions. Whether or not your students win the competition, these activities will stimulate meaningful research, enhance science knowledge, and develop higher level thinking skills.

In accordance with the National Science Education Standards, your students will:

- Learn core concepts of Earth and Space science.
- Develop skills of scientific inquiry.
- Experience the unifying concepts and processes of science.
- Gain new skills with technology (computers, Internet, image and data analysis).
- Appreciate the multi-faceted roles of science in our society
- Work collaboratively as team members.
- Communicate more clearly and effectively.

Designing a Mars Mission

The Mars Pathfinder mission demonstrates how a dedicated group of scientists and engineers design a mission and learn from the new data it provides.

I. General Research

Begin by exploring Mars at whatever level of detail is appropriate for your students. They might simply begin with whatever is in the science textbook. Or they might explore web sites with detailed images of the surface of Mars from past and current missions (see "Resources" on p. 18). In this phase, you raise your students' general level of understanding about Mars and pique their curiosity about the planet.

II. Interesting Questions

Encourage your students to consider not just what is known about Mars but also what is not known (see "Mysteries of Mars" on pg. 5). Make a list of questions that interest your students and review it to determine which:
a) are most interesting to your students; and b) could serve as the focal point for the mission they will design. Narrow the list to one or a few core questions.

III. Focused Research

Have your students do more detailed research relating to the question(s). Your students should investigate the relevant science, using images and other data from Mars, and learn about existing or anticipated instruments that might be useful in your proposed mission. As a result of this research, your students select a primary question, further refine it, and generate initial ideas on how a mission might gather data to answer the question.

IV. Design the Mission

This is the core of the work. As with NASA's own missions, your students need to consider two inter-related elements: the scientific research that they propose, and the engineering challenges in terms of selecting instruments and tools that will provide the data they need (and can reasonably fit on a spacecraft). The mission could involve an orbiter, a lander, a robotic rover, a sample return, a human presence, or whatever creative idea your students conceive. As per NSIP guidelines (see pg. 2), focus on the science research goals. Briefly describe (but do not provide detailed designs for) the spacecraft, instruments, or tools. Think carefully about the data needed in order to answer the research question(s). Remember that a human mission is far more costly and risky, so the ends must justify the means.

V. Prepare the Entry

Finally, your students present their ideas, research and design in their NSIP Mars Mission Proposal, following the NSIP guidelines. The entry will be judged on the quality of the research and mission design, which must be communicated clearly and effectively. Include maps and images indicating optimal landing sites or targets for orbital study, and discussion of why this is an important mission and research topic.

Basic Concepts About Mars

This summary provides basic information about Mars and Mars exploration. You can learn much more through science textbooks, the web, books from libraries and book stores, and reports in the news (see "Resources" on p. 18).

Channels formed by flowing water.

Mars is a planet in our solar system.

Earth is the third planet from the Sun; Mars is the fourth. Since Mars is farther away from the Sun, Mars takes longer to orbit the Sun (687 days for Mars versus 365 days for Earth). The surface of Mars is colder than Earth's (the average temperature is −63°C, ranging from −125 to 22°C).

Mars is smaller than Earth.

Mars' equatorial diameter is 6794 km, which is about half of Earth's. Mars has a mass of 6.4 x 1023 kg, which is about a tenth of the mass of Earth. If you weighed 100 pounds on Earth, you would weigh only 38 pounds on Mars (Gravity is proportional to the mass and inversely proportional to the square of the distance between the planet's center and the object it is attracting.)

The surface of Mars is very dry.

Scientists believe that Mars had liquid water on its surface early in its history (3 to 4 billion years ago). However, there is no evidence of liquid water currently on the surface (although there may be some liquid water under the surface).

The polar regions are the coldest part of the planet.

Mars has ice caps that shrink and grow with the seasons. The polar caps are a combination of water ice and carbon dioxide ice, with layers of dust. Earth-based telescopes, such as those used by amateur astronomers, can detect changes in the size of the polar caps.

The forces shaping the surface changed over time.

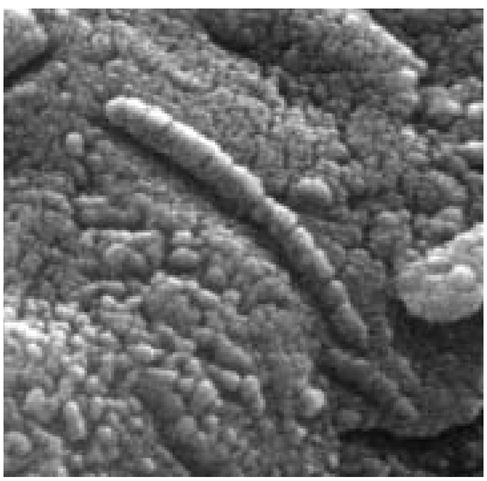
Early in Mars' history, the primary forces acting on the surface were impacts that caused craters, volcanic activity, surface rifting and catastrophic floods. Currently, the primary force is erosion due to strong gusting winds associated with seasonal dust storms.

The atmosphere is extremely thin.

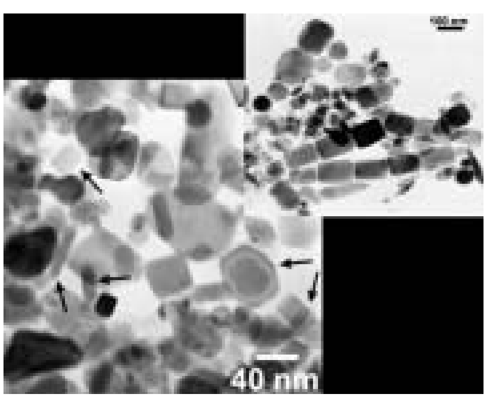
Mars' atmospheric pressure is about 1/100th of Earth's. It consists mostly of carbon dioxide (95.3%), nitrogen (2.7%) and argon (1.6%). Oxygen is only 0.13% of the atmospheric composition. Although clouds (carbon dioxide and water ice) occasionally form, it does not rain. The Martian atmosphere does not block out ultraviolet rays. Therefore, humans could not survive in such conditions without a pressurized space suit, oxygen supply, and protection from the ultraviolet rays.

Mysteries Of Mars

Mars is still a mystery planet, with many unanswered questions. Current and future missions to Mars are designed to help scientists answer them. Your students might consider these mysteries as possible research domains for your mission designs.



Possible nanofossil found in Martian meteorite ALH84001



Magnetite crystals embedded in the carbonates in ALH84001

Water on Mars?

What role did water play in Mars' early history? There is evidence of flooding, but did water accumulate in pools, lakes, and oceans? How long was this wet period in the history of Mars? Where did the water go? Is there liquid water under the surface of Mars? Do recent images (e.g., above) from Mars Global Surveyor mean that water still flows today?

Mission example: Your students might select landing sites that show evidence of past water, and then design a spacecraft to dig hundreds of meters below the surface, searching for possible liquid water under a frozen layer of ice.

Life on Mars?

Did or does life exist on Mars? We have seen possible evidence of past life in a meteorite that came from Mars, but this evidence is still quite controversial. Could life have formed in the early wet period of Mars' history? Could life still exist in sub-surface pockets of water? Would life have been single cells, like bacteria on Earth, or might it have evolved into multi-cellular or other more advanced life forms? How might we search for fossils from past life on Mars? How do we avoid contaminating Mars with life forms from Earth and vice-versa?

In an August 2002 press release, NASA announced the publication of new results in the continuing search for ancient Martian life. "In the latest study of a 4.5 billion-year-old Martian meteorite, researchers have presented new evidence confirming that 25 percent of the magnetic material in the meteorite was produced by ancient bacteria on Mars." Find out more at ***http://mars.jpl.nasa.gov/newsroom/pressreleases/20020802a.html***.

Mission example: Your students might plan a human mission to Mars, with a team of geologists, biologists, and chemists who would explore several priority sites for rock fossils. The base station might have equipment to analyze the rocks and slice open the most likely candidates for more detailed examination by microscopes.

Surface Features?

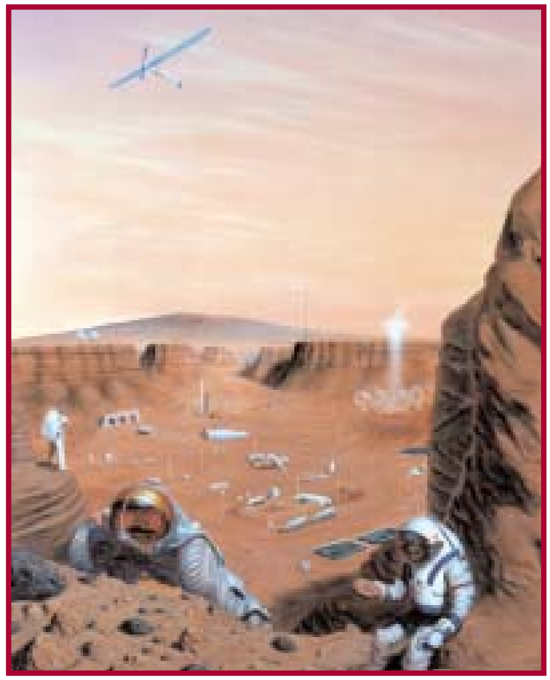
How has the surface of Mars changed over time? How long were its volcanoes active? Did Mars have plate tectonics, as on Earth? Why is there such a big difference between the heavily-cratered Southern hemisphere and the relatively smooth Northern hemisphere? What caused the huge Vallis Marineris rift valley? What can we learn about the composition and water content of the surface from the different types of craters found on Mars? How old are the gullies recently imaged by Mars Global Surveyor?

Mission example: Your students might plan an orbital mission with a high-resolution camera to study different types of craters to better understand why they differ. The plan might specify which craters to explore, based on existing Mars maps and images and on current understanding of craters.

Atmospheric Dynamics?

Why is Mars regularly enveloped by huge planet-wide dust storms? What can we learn about the occasional clouds? How strong are the winds and how have they re-shaped the surface? How does the temperature and composition of the atmosphere change from the surface to the highest levels of the atmosphere? How does the atmosphere change from one season to the next?

Mission example: Your students might propose a balloon-like spacecraft that can float in the Mars atmosphere, carried by winds at altitudes determined by controls on the spacecraft. Your students might also specify which types of instruments to include.



Human Presence?

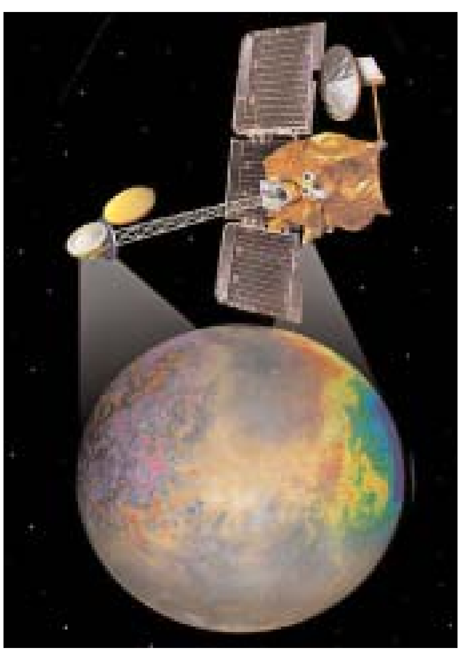
How could humans survive such a long flight to and from Mars (one way is 7–10 months)? What kind of life-support facilities will we need on Mars? What kind of space suits or other protection will we need to explore the surface? Can we manufacture fuel from resources in the rocks and atmosphere of Mars? What types of exploration can best be done by robots instead of humans (and vice-versa)? Can we extract water from below the surface, or by melting permafrost or ice from Martian ice caps?

Mission example: Your students might design two missions, one robotic and one human, both focusing on the same research topic (such as the search for subsurface water). Your students might also compare and contrast them in terms of the effectiveness, relative merits, and associated challenges.

NASA's Missions to Mars

Did you know that there have been 31 missions to Mars to date? To view chronology, visit ***http://mpfwww.jpl.nasa.gov/missions/log***. To learn about Mars missions past, present, and future visit ***http://mpfwww.jpl.nasa.gov/missions/***.

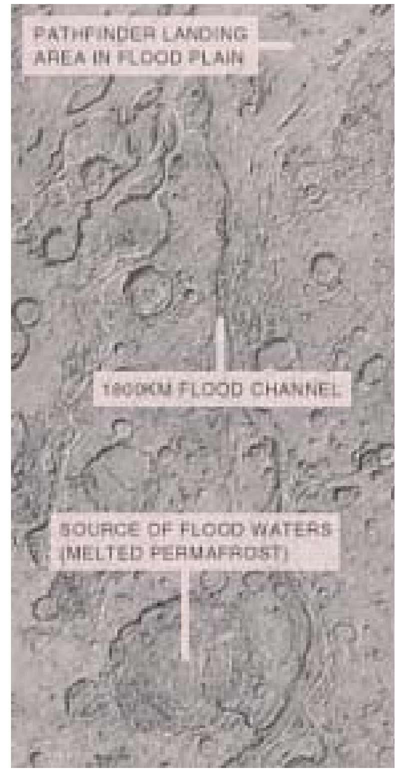
The following examples from current and future missions illustrate the wide variety in spacecraft design (see "Resources" on p. 18 for more details). Students will need to select the type of mission that best meets their research goals. Options include fly-by, orbital, lander, rover, sample return, human missions, and whatever other creative ideas students might conceive. Depending on the orbital track, it takes about 7 to 10 months for a mission to go from Earth to Mars, traveling at about 25 km/sec.



Currently Active Missions

Mars Global Surveyor became the first successful mission to the red planet in two decades when it launched November 7, 1996; it entered orbit on September 12, 1997. After a year and a half trimming its orbit from a looping ellipse to a circular track around the planet, the spacecraft began its prime mapping mission in March 1999. The mission has studied the entire Martian surface, atmosphere, and interior, and has returned more data about the red planet than all other Mars missions combined.

Among key science findings so far, Global Surveyor has taken pictures of gullies and debris-flow features that suggest there may be current sources of liquid water, similar to an aquifer, at or near the surface of the planet. Data from the spacecraft's laser altimeter have given scientists their first 3-D views of Mars' north polar ice cap. (See NASA's Mars Mission website ***http://mars.jpl.nasa.gov/mgs/***.)



Future Missions

2001 Mars Odyssey is an orbiting spacecraft designed to determine the composition of the planet's surface, to detect water and shallow buried ice, and to study the radiation environment. The surface of Mars has long been thought to consist of a mixture of rock, soil, and icy material. However, the exact composition of these materials is largely unknown. Odyssey will collect images that will be used to identify the minerals present in the soils and rocks on the surface and to study small-scale geologic processes and landing-site characteristics. By measuring the amount of hydrogen in the upper meter of soil across the whole planet, the spacecraft will help us understand how much water may be available for future exploration, as well as give us clues about the planet's climate

history. The orbiter will also collect data on the radiation environment to help assess potential risks to any future human explorers, and can act as a communications relay for future Mars missions. For more information visit ***http://mars.jpl.nasa.gov/odyssey/***.

To learn about a unique opportunity for students to participate in Mars research, using data from the THEMIS instrument aboard the Odyssey, visit the Mars Student Imaging Program at ***http://msip.asu.edu/***.

Rover Twins to Mars in 2003—Both Mars rovers currently are planned for launch on Delta II rockets from Cape Canaveral Air Force Station, FL. The first mission is targeted for May 22, with the second launch slated for June 4. After a seven-and-a-half month cruise, the first rover should enter Mars' atmosphere January 2, 2004, with the second rover bouncing to a stop on the Martian surface January 20.

The rovers will be exact duplicates, but that's where the similarities end. Relatives of the highly successful 1997 Soujourner rover, these 300-pound mobile laboratories may look and act alike, but they're going to decidedly different locations.

"For the first time, science and technology have given us the capability to explore alien planets in ways that used to exist only in science fiction movies," said Dr. Weiler [Associate Administrator for Space Science, NASA Headquarters]. "To have two rovers driving over dramatically different regions of Mars at the same time, to be able to drive over and see what's on the other side of the hill—it's an incredibly exciting idea." Dr. Weiler added, "I think everyone on Earth who has ever dreamed of being an explorer on an alien planet will want to go along for the ride as we explore the surface of Mars." (from NASA Press Release, August 10, 2000, ***http://spaceflight.nasa.gov/spacenews/releases/h00-124.html***)

NASA expects to launch additional missions, each with its own unique set of instruments, with at least one new mission every 26 months, when Mars and Earth are aligned for the most energy efficient travel. NASA is exploring options for a Mars sample return mission, and in the long-term, a human mission. Several of these missions involve collaborations with other countries, especially Japan and the European Space Agency.

Mars Express—NASA is participating in a mission planned by the European Space Agency and the Italian space agency called Mars Express. It will explore the atmosphere and surface of Mars from polar orbit. The mission's main objectives are to search for sub-surface water from orbit and to deliver a lander to the Martian surface. Seven scientific instruments onboard the orbiting spacecraft will study the Martian atmosphere and the planet's structure and geology.

The lander is called Beagle 2 after the ship in which Charles Darwin set sail to explore uncharted areas of the Earth in 1831. After coming to rest on the surface, Beagle 2 will perform exobiology and geochemistry research. For more information, see the Mars Express home page, ***http://mars.jpl.nasa.gov/missions/future/express.html***.

For the first time, science and technology have given us the capability to explore alien planets in ways that used to exist only in science fiction movies.

—Dr. Ed Weiler
Associate Administrator
for Space Science, NASA HQ

Prepare Your Entry

The Research Process

The process described here is intended for use with all age groups. Two important points must be kept in mind. First, the process of research is not a simple sequence of steps, like recipe or a lab report. It is really about deepening the original question, so the process involves a lot of going back to re-examine earlier assumptions. Second, since your students are of different ages and ability levels the process that appears here is intended to be adaptable. ***The main point of research is to find an interesting question, to pursue it, to deepen one's understanding of it, and to find answers along the way***. In this pursuit, older and more advanced children are expected to use more of the language and tools of science than their younger counterparts will. We have tried to reflect this understanding in the judging rubric as well.

I. Selecting a Topic of Interest

Scientific inquiry can originate from any number of topics. The switch from an interesting topic to a scientific investigation happens when the words "I wonder …" cross the mind: A research question is born.

II. Background Research

What is known about the topic? Discuss, read, browse web sites listed in this Guide, look at images, and discuss ideas. This is a recurring part of all research which can help students focus the research question and mission design. It will shorten the search for suitable data, images, maps, etc.

III. Turning the Question into a Hypothesis

How does a question that begins with "I wonder …" become a full-fledged research question? First, does the question even admit of an answer, and if so, can the question be answered by your students within the limits of their resources (e.g., literature at the right reading and conceptual level, equipment, access to information, etc.)? Second, if at least part of the question is testable, then it is on its way: such questions could be answered with the right data, information, images, maps. A hypothesis is a testable statement about the research question. Because test results will either support or falsify it, a good hypothesis can guide research toward answers. A researcher makes a question testable by identifying variables and proposing a relationship among them. For younger students, the process of isolating variables and using controls can be expressed in terms of "doing a fair test."

IV. Planning

Once the question is focused, and testable parts are identified, there needs to be a plan of action: What sort of mission could bring back the data and information required to answer the research question? What factors are going to count in favor of the proposed design? What are the key design challenges? Can the data and information needed to address research and design questions be obtained within a reasonable amount of time and effort? Time-limitation is an important factor to consider in shaping any research project.

V. Analysis
How will students analyze the data, images, maps, etc., that they've collected in order to make the case for or against the hypothesis? What sorts of relationships will students look for? What sorts of diagrams and graphs will display demonstrate these relationships clearly and convincingly?

VI. Communicating the Findings
When the research is done and the dust has settled there is one last and crucial challenge: to present the mission purpose and design in an engaging way that informs, educates, and convinces.

Entry Components

I. Mission Purpose
Define your Mars-related research question. Explain why you are interested, why you chose your research question, and how your proposed mission will help you answer your question. Be brief, clear, and focused.

II. Background
Explain the science and engineering challenges involved in finding the answer to your research question. Use a variety of sources about Mars and space missions.

III. Mission Design
Describe the science details of your mission, including the research focus, type of mission (robotic, orbital, human, sample return, or other), data to be collected, target sites for landing or orbital study, and contingencies for unknowns. Assume that the spacecraft has successfully reached the desired orbit or landing site and focus on the research goals and methods rather than on the engineering specifications. Briefly describe (but do not provide detailed designs for) the spacecraft, instruments, and tools, and explain how these will help answer your research question. Include illustrations, maps of Mars, and images of other data to convey concepts clearly. If you make spacecraft models, include a photograph.

IV. Resource Credits
List all reference books, periodicals, web sites, and people (including names, work titles, and type of help they provided) who contributed to your research. This section is not included in the word count.

To get a detailed description of how these components will be evaluated, examine the Judging Rubric on the following pages.

Design a Mission to Mars Judging Rubric

Grades 5–8, 9–12

This rubric is designed for all grade levels. Teachers should adapt the rubric to match their students' ability levels.

Entries must meet the following minimum standards. Entries not in compliance will not be judged.

- Entries must propose a research question about Mars, with a clear research objective.

A. RESEARCH & ANALYSIS 70 Points Maximum

LEVEL	**1. RESEARCH QUESTION AND HYPOTHESIS** *What is the research question? Does the hypothesis focus the investigation of that question? What variables were selected for study?*	**2. BACKGROUND RESEARCH** *Does the report demonstrate a clear understanding of relevant facts and theories?*	**3. MISSION PLAN** *Is there a clear mission plan and does it address the research question and hypothesis?*	**4. DATA AND GRAPHICS** *Does the report utilize relevant data, images, maps, and graphs to support the research question and mission plan?*	**5. ANALYSIS AND CONCLUSIONS**
0	No research question or hypothesis is stated.	Understanding is confused; most statements about basic facts and theories are missing or incorrect.	No clear plan is apparent.	Data or graphs are present but have little relevance to the research question, hypothesis, or analysis.	Background research, data, images are poorly utilized, and not relevant to the research question and the hypothesis.
1	A research question or hypothesis are present, but both are poorly stated and may contain inaccuracies.	Understanding is somewhat clear; some statements about basic facts and theories are incorrect or missing.	Plan is unclear, most steps are missing or confused; it relates poorly to the research question.	Data and graphs are present and have some relevance to the research question and may serve as the basis for analysis.	Background research, data, images are utilized to make a weak case about the research question and the hypothesis.
2	A clear research question and hypothesis are stated but not testable, or variables are not identified.	Understanding is mostly clear; most statements about basic facts and theories are relevant and correct; relevant resources are cited.	Plan is somewhat clear, main steps are present, and is somewhat relevant to the research question and hypothesis.	Data and graphs strongly address the research question and serve to justify the analysis; presentation lacks labels, legends, or captions.	Background research, data, images are utilized to make a fair case about the research question and the hypothesis.
3	The research question is clear, the hypothesis is testable, and variables are identified.	Confident understanding of relevant facts and theories; relevant resources are cited from multiple sources (i.e., not exclusively Internet).	Plan is clearly stated, most steps are present, and will yield data relevant to the research question and hypothesis.	Data and graphs strongly address the research question and justify the analysis; presentation of data lacks little or nothing.	Analysis shows originality and creativity, makes a good case for research question, hypothesis and mission plan; deeper understanding of research question.
4	The research question is clear, hypothesis is focused and compelling; variables are identified as dependent, independent, and control (if appropriate).	Demonstrates mastery over relevant field of facts and theories; relevant resources are cited from multiple sources (i.e., not exclusively Internet).	Plan will clearly yield data that address the research question and hypothesis in a compelling way.	Data and graphs make a compelling case about the research question and hypothesis; data are presented clearly and informatively.	Analysis shows originality and creativity, makes a compelling case for the research question, hypothesis and mission plan; discusses possible sources of error.
	Level _____ × 3.75 = ______ points	Level _____ × 3.75 = ______ points	Level _____ × 3.75 = ______ points	Level _____ × 2.5 = ______ points	Level _____ × 3.75 = ______ points

Subtotal points from this page __________

B. COMMUNICATION 30 Points Maximum

LEVEL	6. PRESENTATION OF RESEARCH AND CONCLUSIONS	7. RESOURCE CREDITS
0	Poor presentation, evidence of last minute efforts, no clear organization, significant components are missing.	Resources are not present.
1	Presentation is plain, but lacks clear organization, not engaging; poor presentation of data and graphs.	Minimal resources are cited.
2	Presentation is plain, somewhat clearly organized, somewhat engaging; data and graphs are presented adequately.	Contains citations from few sources; citations are indirectly related to the report.
3	Presentation is creative, clearly organized, and engaging; data and graphics are informative.	Contains some relevant citations from multiple sources (i.e., not exclusively Internet); citations are directly related to the report.
4	Presentation is creative and original, clearly organized; engaging and persuasive; data and graphics are informative.	Contains many relevant citations from multiple sources (i.e., not exclusively Internet); citations are directly related to the report.
	Level _____ × 3.75 = ______ points	Level _____ × 3.75 = ______ points

Subtotal points from this page __________

Total points __________

Sample Learning Activities

This section describes activities presented as sample research themes to help your students get started.

Research Theme Sample 1

Exploring Craters

In this activity, your students use the web to explore sample images of the surface of Mars and learn about the status of current missions to Mars. This leads to questions about Martian craters. A similar approach could lead to other Mars-related topics.

I. Learn about the Mars Global Surveyor mission.

Log on to the NSIP web site ***(http://www.nsip.net)*** which serves as a central entry point into a rich variety of Mars-related web sites. From this site, go to JPL's Mars web site. JPL is the Jet Propulsion Laboratory, NASA's lead center for the Mars missions. This site provides the current status and recent findings of active Mars missions, such as Mars Global Surveyor (MGS). Use this site to read about the status of MGS, learn about its design and instruments and look at some of the most recent sample images.

II. Study some sample images.

Select a few of the images that seem especially interesting. Download and print them. Have your students study these images, try to identify features such as craters, volcanoes and valleys and think about what might have formed these features. Use the captions, your science textbook, books about Mars, the web site, or other related sources to help your students develop a better understanding of the features in the sample images.

III. Focus on craters.

Perhaps your students have shown a special interest in craters which cover much of the surface of Mars. Have your students compare the sizes, shapes, and locations of the craters. For example, some craters have clearly defined edges, others have smoothed edges, and others appear to ooze out from the edges. Ask your students what might cause these differences.

IV. Try some classroom experiments.

Have students model some of the features they see. They might make a tray of mud and then drop rocks of different sizes into the mud, to simulate crater formation. Try different consistencies of mud or different heights for the rocks, or throw the rock at a glancing angle. These classroom experiments help students understand the planetary impact processes.

V. Define the research question for your mission.

Your students might notice that Mars' Northern hemisphere is less heavily cratered than the Southern hemisphere. Have your students examine these differences more closely. This might lead to a research question for your mission, such as "Why is there such a striking difference in crater density between the Northern and Southern hemispheres?"

VI. Design a mission.

This research question in turn might lead your students to design an orbital mission to get detailed images from the two hemispheres for a comparative analysis, or a surface exploratory mission with two teams of geologists, each collecting surface data from one of the hemispheres.

Research Theme Sample 2

Searching for Water on Mars

In this activity, your students focus on evidence of surface water in Mars' ancient past. The nature, scope and duration of this "wet period" are active topics in current Mars research.

I. Start with the Mars Pathfinder landing site.

The Pathfinder mission is a good starting point for studying water. Scientists speculate that there were major floods of the area around the landing site a few billion years ago and designed Pathfinder to gain data to support or refute this theory.

II. Trace the floods.

With this initial background on Mars Pathfinder, have your students examine evidence of flowing water in images and maps of this region of Mars. For example, your students will see "tear drop" shapes around craters that were probably caused by water flowing around craters. With a larger view of the region, your students can trace the 1,800 kilometer long Ares Vallis channel that carried immense amounts of water in a series of short-lived floods. For more details on how to trace this flood, read "Images from Mars and the Stories They Tell," available through the NSIP web site.

III. Model flowing water.

Make a stream table in your classroom, using a long tray such as an inexpensive wallpaper tray. Fill it with sand roughly one inch deep. Then slightly elevate one end and slowly pour water into it. Notice the erosion pattern. Experiment with different slopes of the tray, pouring water at different rates, placing objects on the sand, etc. Try to replicate the tear-dropped shape of water flowing around an object, as seen in the Pathfinder landing site image.

Closeup of Pathfinder landing site.

IV. Find other evidence of water.

Using other images of Mars, have your students find other possible evidence of past water on Mars. Find other valleys that might have carried water, mud flows around craters, or possible evidence of shorelines. Study examples described by Mars scientists and then have your students search on their own for similar evidence in other images.

V. Design a mission.

Your students might decide to focus their mission on extending this search for evidence of past water. For example, they might select specific sites that have the most compelling evidence of past water as seen in the orbital images and then recommend robotic rover missions to those sites. The mission design would include images showing the specific target locations, and a description of the specialized cameras and instruments that the rover(s) would need.

Research Theme Sample 3

Searching for Life on Mars

Humans have long been fascinated with the prospect of life on Mars. This image shows what some believe may be a "nano-fossil"—possibly an extremely small single cell life form found on a meteorite from Mars. However, others believe it is too small to have been alive. This controversy points out the importance of on-site information directly from the Martian surface or a sample return mission.

I. What is life?

First, ask your students to define life on Earth. Their answers reveal their assumptions about the nature of life. For example, definitions might include only "higher" life forms such as animals and humans or might include extremely small single-cell organisms. Then ask your students to list the requirements for life to emerge on a planet. Earth-centric answers focus on Earth's unique combination of land, air, water, solar energy, and a suitable temperature range. Universal answers would be more general.

II. Where is life on Earth?

Ask your students to describe where life exists on Earth. The obvious answers focus on areas where we see vegetation and animals thriving. The less obvious answers include extreme environments such as the tallest mountains, the deepest parts of the ocean, the cold polar regions, the hot deserts, the upper reaches of the atmosphere, and deep within the surface of the Earth.

III. Are there potential barriers to life on Mars?

Have your students list potential barriers (or challenges) to life on Mars. For example, there is no liquid water on the surface of Mars; the atmosphere is very thin and has very little oxygen; there is no ozone layer to protect life from lethal radiation. Speculate on how life on Mars might evolve unique solutions to these problems. Also, consider how Mars might have been a more conducive environment a few billion years ago, when it was warmer and wetter. How does the recent discovery of gullies on Mars impact the search for life?

IV. Look for life on Mars.

Given these challenges to the emergence of life, where should a Mars mission look for either fossils or current life? Have your students develop a list of possible environments for life: a) in the ancient past when Mars had surface liquid water; and b) in the present. These questions focus on environments with liquid water since it is such a useful (if not essential) factor in the emergence of life.

V. Design a mission.

A mission searching for fossils might target places with the most compelling evidence for lakes that lasted for an extended period of time or your students might search for current life, first through an orbital reconnaissance to detect sub-surface water, then with a human mission to the surface with drilling equipment and a base camp with advanced microscopes and equipment for biological analysis.

Resources

These resourcers are updated periodically. Check the Design a Mission to Mars web site at ***http://www.nsip.net/competitions/mission/index.cfm*** for the best and most up-to-date version.

NSIP Competition Announcement

Full details for the NSIP competition are presented in the official NSIP Competition Announcement (EW-2001-07-135-HQ). To get a copy:

- download from the NSIP web site—***http://www.nsip.net***—or
- call to request a printed copy at 1-800-848-8429, toll free.

NSIP Web Site

The NSIP web site provides additional information, learning activities, and linkages to sites with Mars images, data, and other resources (including all web sites listed here):

http://www.nsip.net

NASA Educational Resources

NASA has a multi-faceted education and public outreach program, including a comprehensive web site, printed educational materials, image sets, and other resources.

NASA Home Page:
http://www.nasa.gov

NASA Spacelink:
http://spacelink.nasa.gov

NASA CORE:
http://spacelink.nasa.gov/CORE

The guidebook, *How to Access Information on NASA's Education Program, Materials and Services* (EP-1998-03-345 HQ), is available through Spacelink.

For further information about NASA's Educator Resource Centers:
http://education.nasa.gov/ercn

Mars Web Sites

MARS IMAGES AND MAPS

JPL's Mars Web
http://marsweb.jpl.nasa.gov

Center for Mars Exploration
http://cmex-www.arc.nasa.gov

NASA's Planetary Photojournal
http://photojournal.jpl.nasa.gov

Planetary Data Set
http://www-pdsimage.JPL.nasa.gov/pds

Malin Space Science Systems
http://www.msss.com

NASA Image Exchange
http://nix.nasa.gov

MARS EDUCATION MATERIALS

JPL's Mars Education Program
http://mars.jpl.nasa.gov/education/modules/webpages/modulepage.htm

Mars Team Online
http://quest.arc.nasa.gov/mars

ASU Mars K-12 Program
http://emma.la.asu.edu/neweducation.html

Using Mars Images in Education
http://www.terc.edu/handson/s97/imagesmars.html

OTHER MARS WEB SOURCES

JPL's top-level web site
http://www.jpl.nasa.gov

Goddard's list of Mars links
http://nssdc.gsfc.nasa.gov/planetary/planets/marspage.html

Hawaii Astronomical
http://www.hawastsoc.org/solar/eng/mars.html

Whole Mars
http://www.reston.com/astro/mars/catalog.html

Press Release on Recent Evidence of Liquid Water on Mars
http://nssdc.gsfc.nasa.gov/planetary/ice/water_mars.html

Planetary Society
http://planetary.org

MARS EMAIL LISTSERVE

For email news and progress reports on the Mars 00 missions, send an email message to: jplnews@jpl.nasa.gov. Leave the subject field blank, and type: *subscribe mars00* in the body of the message.

Mars and Astronomy Books

Exploring the Planets, Eric Christiansen, ISBN 0-02-322421-5

Mars, Peter Cattermole, ISBN 0-412-44140-3

NASA Atlas of the Solar System, Greeley and Batson, ISBN 0-521-56127-2

New Solar System, Beatty and Chaikin ISBN 0-933346-55-7

Planetary Landscapes, Ronald Greeley, ISBN 0-412-05431-0

Smithsonian Guide to the Planets, Thomas Watters, ISBN 0-02-860404-0

Uncovering the Secrets of the Red Planet, Paul Raeburn, ISBN 0-7922-7373-7

Water on Mars, Michael Carr, ISBN 0-19-509938-9

Periodicals

The Planetary Report
The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106-2301
Phone: 626-793-5100

Mars Underground News
The Planetary Society (see above address)

Posters

Two Faces of Mars, Item #1338, $10.95
MarsScape, Item #1248, $19.95

Both available from:
Spaceshots
26943 Ruether Ave. Suite R
Santa Clara, CA 9135
1-800-272-2779
http://www.spaceshots.com

An Explorer's Guide to Mars,
Item #505, $6.00
Available from:
Planetary Society (see above address)

Maps from the U.S. Geological Survey

Topographic Map of Mars (1:25,000,000) (1 map) I-961

Topographic Map of Mars (1:15,000,000) (3 maps) I-2160

Map of Olympus Mons to Ares Vallis I-1618

Olympus Mons Volcano I-1379

Close up of Tharsis volcanoes I-1922

Valles Marineris, the Martian Grand Canyon I-1253

Channels and water eroded landforms I-1652

Map of region where Pathfinder and Viking landed I-1551

Close-up of Pathfinder's landing site I-1345

All maps available from:
USGS
Box 25286
Federal Center, Building 810
Denver, CO 80225
1-800-435-7627

Additional Reading

P primary ***I*** middle school
E elementary ***A*** advanced 9-12+

The New Book of Mars. Nigel Hawkes. Illustrated by Richard Rockwood. Copper Beech/Millbrook. 32 pp. Library ISBN 0-7613-0811-3; Paperback ISBN 0-7613-0731-1. (I) Good information and format, coupled with outstanding artwork, make this an excellent overview of Mars and of our investigations and speculations about this planet. The Mariner, Mars Pathfinder, and Surveyor '98 missions, as well as planned future explorations, are well described. Glossary. Index.

Close Encounters: Exploring the Universe with the Hubble Space Telescope. Elaine Scott. Illustrated with photographs. Hyperion. 64 pp. Trade ISBN 0-7868-0147-6; Library ISBN 0-7868-2120-5. (I, A) An easy-to-understand text tells the story of the Hubble Space Telescope and the information received since its deployment in space. Actual photographs of Hubble discoveries accompany the narration. Index.

The Kingfisher Young People's Book of Space. Martin Fedfern. Illustrated with photographs and prints. Kingfisher. 96 pp. Trade ISBN 0-7534-5136-0, $19.95. (I) This overview of the subject starts with an up-to-date report of observations and explorations of our solar system and ends with a description of our place in space and time in the universe. The book's layout, with outstanding pictures and text, complements this engaging journey through our space.

DK Guide to Space: A Photographic Journey Through the Universe. Peter Bond. Illustrated with photographs from NASA's robotic space probes and the Hubble space telescope. DK Publishing. 64 pp. Trade ISBN 0-7894-3946-8. (A) Through vivid photographs, the reader is presented with information on the components of the solar system and universe. Each topic is described in a two-page layout that integrates scientific information with striking illustrations. Some of the topics included are the sun, planets, space exploration, galaxies, and stars. Index.

DK Space Encyclopedia. Heather Couper and Nigel Henbest. Illustrated with charts, maps, and photographs. DK Publishing. 304 pp. Trade ISBN 0-7894-4708-8. (A) This comprehensive guide to astronomy and space travel, arranged by an extensive list of topics, will help young stargazers better understand the work done by top scientists. Stunning, detailed images plus instructions for building a simple telescope make this book essential for anyone interested in space and astronomy. CD-ROM, How to Use This Book section, Reference section, Index.

The Reader's Digest Children's Atlas of the Universe. Robert Burnham. Illustrated by Wildlife Art Ltd. Reader's Digest Children's Books. 128 pp. Trade ISBN 1-57584-373-0, Library ISBN 1-57584-379-X. (I, A) Beautiful illustrations and a strong layout create an eye-catching, informative reference. This atlas visits the planets in our solar system as well as asteroids, comets, and meteors before proceeding to the stars and galaxies of deep space. Suggested activities for the reader encourage hands-on exploration of the concepts presented. Glossary, Index, Universe Fact File (includes facts on our solar system and other celestial objects, astrological and technological events, timeline of astronomy, and universal records).

Space Station Science: Life in Free Fall. Marianne J. Dyson. Illustrated with drawings by Dave Klug and photographs from various sources. Scholastic Reference. 128 pp. Trade ISBN 0-590-05889-4. (I) Welcome aboard the International Space Station! Readers are introduced to the numerous systems that keep the space station up and running and the complexities of day-to-day living onboard. Complete with hands-on activities that simulate life in space and full-color illustrations, this book shows what it's like to live in a space station. Foreword by Buzz Aldrin. Glossary, Index, For Further Study.